

MATERIALS OLDER THAN Ca-Al-RICH INCLUSIONS.

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Introduction: Concentrations of refractory lithophile elements (RLEs) in Type B1 Ca-Al-rich inclusions (CAIs) are dominated by submicron inclusions, which are potentially relict grains older than the host CAI. These objects are so common, albeit tiny, that it is often very difficult to find a “pure” melilite.

Analysis Methods: We analyzed Leoville 3537-2 and Allende 5241 with the Caltech Cameca 7f Geo ion microprobe. Each of the analyzed spots contains 40-110 slices (cycles) of 10 elements (Li, Be, Ca, Sc, Ti, Sr, Y, Zr, Ba, and Ce) with each slice excavating a volume approximately 40 μm in diameter by <0.1 μm deep. The data (62 Leoville and 86 Allende spots) were examined in terms of trends as a function of depth within a spot, and for spot to spot variations.

Results: We “filtered” the data for a given depth profile in terms of (a) an “inclusion filtered” (IF), nominally pure, melilite component and (b) Ti-rich inclusions. Mantle melilite, ideally, represents fractional crystallization (FC) dominated by a single phase. This, plus measured partition coefficients [1], permit accurate FC predictions. In profiles dominated by inclusions, the lowest measured RLE concentration gives a nominal upper limit (“UF”) for pure melilite. Data for the core of the CAI ($\text{\AA k} > 50$) demonstrate systematics over an extended \AA k range, but remelting following initial crystallization [2] and co-crystallization of melilite with clinopyroxene and anorthite complicate modeling of late-stage crystallization. However, several elements (e.g., Sc, Be) show large increases at high \AA k , qualitatively consistent with FC. Ti, Sc, Y and Ce show reasonable agreement for mantle melilite, whereas Sr and Ba are much higher than expected from FC, as observed by [3]. For Sc, the UF and IF concentrations in mantle are in reasonable agreement, showing that inclusion-free slices are present in each profile.

Discussion: Automated data acquisition enabled a sufficiently large number of spot analyses, so that statistically significant numbers of IF profiles could be obtained. For melilite in Type B1 CAIs, filtering out Ti-rich inclusions gives IF RLE concentrations in reasonable accord with FC for Ti, Sc, Zr, Y, Ce and Be, although many IF spots still have Sc and Ti concentrations below FC predictions. These data may reflect heterogeneity in the liquid at the time of melilite crystallization with significant concentrations of total Sc and Ti tied up in inclusions.

Identified inclusions are clinopyroxene, perovskite, and pakeite, which are all rich in Ti, Sc, Zr, Y, and Ce but the compositions are varied and complex. Inclusions rich in Ba, and/or Sr are very rare. All of the observed inclusions may pre-date melting of the CAI. The perovskite, in particular, may represent material from a previous generation of Type A CAIs.

Implications for Be isotope chronology. Be profiles show no evidence for inclusions and are uncorrelated with any other element; the distribution is controlled by partitioning. Enhancement of Be in core melilite suggests that most radiogenic enrichment of ^{10}Be or ^7Li is in the core melilite.

References: [1] Beckett J. R. et al. (1990) GCA 54, 1755-1774. [2] Beckett J. R. et al. (2000) GCA 64, 2519-2534. [3] Davis A. M. et al. (1996) 27th Lunar and Planetary Science Conference, pp. 291-292.